Evolution of Titan's atmospheric aerosols under high-altitude ultraviolet irradiation

Sarah Tigrine, Nathalie Carrasco, Ahmed Mahjoub, Benjamin Fleury, Guy Cernogora, Laurent Nahon, Pascal Pernot, Murthy S. Gudipati

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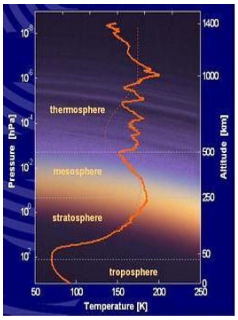


Figure 1: Atmospheric profile of Titan's atmosphere

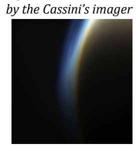
TITAN'S UPPER ATMOSPHERE

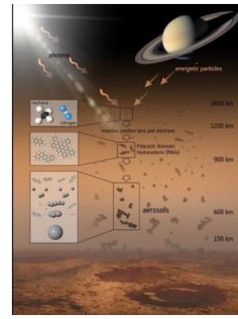
Titan is the biggest satellite of Saturn whose atmosphere is mainly composed of **molecular nitrogen (N_2) and methane (CH_4)** with an average ratio of 98/2 %. [1]

The Cassini/Huygens mission revealed that the **interaction** between those **neutral molecules** and the **UV solar lig**ht leads to a complex **photochemistry** that **produces heavy organic molecules**. When those molecules condense, they will then become **the solid aerosols** which are responsible for **the brownish haze surrounding Titan**. [2][3]

Between 1000 and 600km, the VUV solar radiations are still significant and will continue to modify the physical, chemical and optical properties of those grains. A change in these parameters can impact the radiative budget of Titan's atmosphere.

Figure 2 & 3: Titan seen by the Cassini's imager





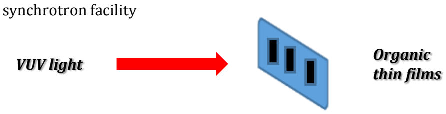
Credits: NASA/ESA

Figure 4: Aerosols' formation in Titan's upper atmosphere

MAIN GOAL: IDENTIFY AND UNDERSTAND THE PHOTOCHEMICAL EVOLUTION OF THE AEROSOLS BY ANALYSING THE IR SIGNATURES AND HOW THEY ARE MODIFIED AFTER BEING EXPOSED TO VUV RADIATIONS

METHOD

The analogues are produced as thin organic films deposited on Si substrates by submitting **a 95-5% N_2-CH_4 molecular mixture to a radio-frequency electron discharge [4]. 20 samples** have been prepared at the same time, **by 45-min deposition**. Then, we estimate that their **thickness is about 300 nm** [5]. We irradiate **the films of Titan's atmospheric aerosols analogues** with VUV synchrotron radiations provided by the DESIRS beamline at the SOLEIL synchrotron facility



In Titan's ionosphere, the aerosols are exposed to the full VUV-solar spectrum, but we focus here on **the Lyman-a (121,6 nm) wavelength** as it is an important contribution.

The **solar VUV-UV** photon flux **reaching the top of Titan's atmosphere** is about **10^{14} photons/s/cm²** [6] while **the DESIRS line** provides a **monochromatic flux of 10^{16} photons/s/cm²**.

The residence time of the aerosols in the **thermosphere** (between 1000 and 600 km) is about the duration of **one Titanian day (10^6 s)** [7]. So we counterbalance our higher photon flux by **shorter irradiation times**: 3h, 10h and 24h.

IR ANALYSIS

We checked that the films are **similar in size and composition** prior the irradiation experiment by **comparing their IR signatures**. We also made sure that they were **homogeneous** by recording their IR signatures **on different 400*400 µm spots** of the same sample.

All the Infra-Red measurements have been performed with a Thermo Scientific Nicolet iN10 MX spectrometer at **the SMIS beamline** at the synchrotron SOLEIL facility. We used the highly sensitive **mercury cadmium telluride (MCT) detector** for a **transmission** analysis.

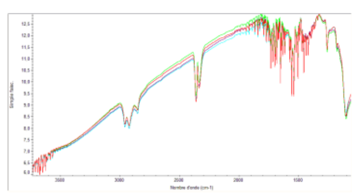


Figure 5: Spectrum of blank substrates. We compared substrates between them but also different positions on the same one.

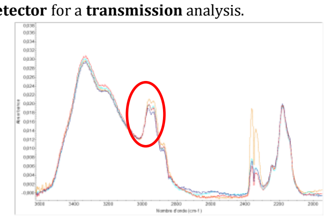


Figure 6: Comparison of different analog films, We notice some slight differences between some samples.

→ We can take only **one reference for the blank substrates** signature

→BUT the **analog samples are not exactly homogenous** between them.

RESULTS

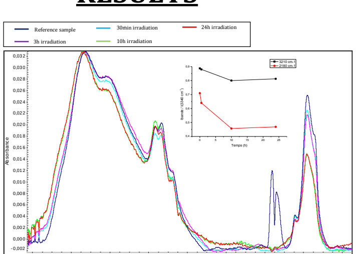
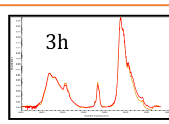
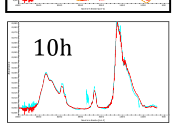
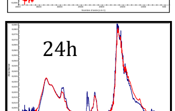


Figure 7: Evolution vs time of the IR signatures of the samples with Ly-a irradiation







Kinetics at Ly-a

- **Decrease of two bands**:
  - C-H at 2950 cm^{-1}
  - C-N at 2180 cm^{-1}
- But the **decrease reaches saturation** after few hours

→ **Are the samples too thick?**

To be Continued…

- Test other wavelengths: **95 nm** (ionization effects?) or **190 nm** (soft UV)
- **Slimmer** analog films
- Gather data on **the absorption cross section** of the aerosol analogs

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